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ABSTRACT

This paper reports a study which examined the relationships of various facets of sensorimotor performance to abilities measured by a developmental examination of a sample of full-term and pre-term infants nine months after expected term date. This study addressed three questions: (1) Are there differences in the sensorimotor development of term and pre-term infants? (2) Can the internal structure of the sensorimotor scales be determined by a single factor or by multiple factors? (3) Do sensorimotor scales provide an added dimension to the measurement of infant cognition above that provided by developmental assessment? Data analysis showed no pre-term and full-term differences in sensorimotor performance and provide support for the view that sensorimotor measures can be used as a method to explore the organization of infant thought and can supply information above that given by developmental evaluations if more than one indicator is used. The question of the relationship between mental and motor abilities is discussed in terms of inconclusive data obtained on gross motor abilities. (GO)

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Early Cognitive Development of Pre-term and Fullterm Infants: Component Structure of Sensorimotor and Developmental Examinations

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Early Cognitive Development of Pre-term and Fullterm Infants: Component Structure of Sensorimotor and Developmental Examinations

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The use of sensorimotor series, as a measure of infant cognition, has increased dramatically in the past few years. In part, this reflects the assumption that these series, derived from Piagetian theory, provide a conceptual framework that differs from that associated with traditional developmental examinations. Furthermore, it is presumed that sensorimotor series permit detailed evaluations of infants' understanding of objects, space, time, causality, object relationships, problem solving, etc. (Casati, I. & Lézine, I., 1968; Escalona & Corman, 1967; Uzgiris & Hunt, 1966) whereas developmental examinations only provide an overall assessment of the child's level of development at a given age period. For both traditional and applied reasons there is considerable interest in determining the relationship between cognitive abilities as measured by sensorimotor tasks and mental performance as evaluated with developmental examinations. However, research directed towards this issue has produced conflicting results.

This is hardly surprising for there has been considerable variability in procedures that have been used. For example, differences are observed in the number and type of sensorimotor tasks that have been given to infants, in the type of developmental examination that has been used, and in the age and ethnicity of the infants that comprised the subject samples. These variables may be very important for there is a substantial amount of infant intra-age and inter-age variability in sensorimotor performance (Kopp, Sigman, Parmelee, 1974). We will describe the previous studies to suggest a few reasons for the inconclusive findings.

Some of the initial correlational research focused on object permanence as the sole dimension of sensorimotor intelligence that was to be compared with performance on a developmental examination. In an innovative study of infant intelligence and affectivity, Décarie (1965) reported very high concordance of object concept formation with performance on the Griffiths Mental Development Scale as measured by the overall score (.91), and the specific scale scores. Of the individual Griffith scales the highest relationship with object permanence was obtained with Scale D, hand and eye development (.91). Décarie computed the coefficients from the rank scores of her entire sample combined which included infants at six age levels (3,6,9,12,16 and 20 months) and three rearing situations (home, adoptive home, institution). Décarie concluded, on the basis of these data and other analyses, that mental age was of primary importance in the development of the object concept. Considering the enormous increase in infant capabilities from 3 months to 20 months, the extreme rearing conditions of her subjects, and the inconsistency of infant rank scores over time it is not surprising that Décarie's grouping of all her subjects led to an extremely high correlation coefficient. Interestingly enough, when Décarie (1969) evaluated thalidomide infants with the same scales she obtained data which suggested a less clear cut relationship. Of 21 children, the majority of whom were between 2 and 2 and one half years, all but two had reached Stage VI of object permanence. Yet, one third of the subjects were borderline or mentally defective and the mean DQ score of the entire sample was 85 (s.d. = 13.86). Therefore, in spite of developmental and motoric problems these children developed a Stage VI awareness of the object.

In another study Golden and Birns (1968), using a sample of 192 Black infants from diverse milieus, evaluated Cattell developmental performance and object permanence (Einstein version). The babies were examined at 12, 18 and 24

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months using a cross-sectional model. One significant correlation (.24) was obtained with the 12 month data. The authors concluded that they were tapping two independent measures of cognitive functioning. A similar conclusion could be drawn from the data presented by Lewis and McGurk (1972) in a study of "infant intelligence." Although these data are somewhat tangential to the major thrust of their study, the authors showed that Bayley Mental Scores and object permanence scores (Einstein series) were significantly related only for the 6 month data. The correlation coefficients were as follows: 3 mo./.24; 6 mo./.6; 9 mo./.16; 12 mo./.09; 18 mo./.23; and 24 mo./.02. These data were derived from a sample consisting of 20 infants, tested longitudinally, who were from a slightly skewed upper-middle class background.

Recently, data were reported from two studies designed to examine several facets of sensorimotor development as well as performance on the Bayley Scales. These data are particularly interesting for the Bayley Scales include some Piagetian type items. King and Seegmiller (1973) used all 7 subscales of the Infant Psychological Development Scales (Uzgiris & Hunt series) with a sample of Black, male, first born infants tested at 14, 18 and 22 months. The sample size varied from a high of N=51 at 14 months to N=33 at 22 months. The reported intercorrelations at 14 months showed significant coefficients between Bayley mental scores and sensorimotor performance of schemata (.32), space (.44), causality (.41) and means (.42); at 18 months mental development was related to schemata (.37) and causality (.46); at 22 months the relationships were with schemata (.32), means (.36) and vocal imitation (.54). At no age was object permanence significantly related to mental performance. These findings suggest low to moderate relationships for developmental abilities as measured by Bayley Scales and sensorimotor performance for this sample, however, with the exception of the schemata scale the relationships are not consistent across ages.

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Gottfried (1975) specifically designed a study to measure the correlates of psychometric and sensorimotor scales. He suggested that previous discrepant findings were due to methodological limitations such as lack of sample age control, use of inappropriate psychometric tests for particular samples, variable testing time periods, and correlational analyses made with scores of insufficient range. Gottfried's study utilized a sample of 207 Black infants ranging in age from about 41 weeks to 68 weeks with a mean age of about 48 weeks. A number of indices were measured including performance on the Bayley Scales, sensorimotor development, socio-economic variables, activity, and physical development. Of interest are the correlations obtained between Bayley mental scores and sensorimotor measures of object permanence (Einstein series) and schemata (Uzgiris & Hunt series). The coefficient for object permanence and mental score was .47, for the schema scores they were .67, .63, .84 depending on the type of schema scoring system used by the author. Gottfried's analyses led him to conclude that psychometric and sensorimotor scales overlap considerably. He suggested that both schemata scales and the Bayley tap a variety of the same behaviors, hence the high intercorrelations. The author further suggested that motor skill development accounted for a large portion of the variance of sensorimotor performance. However, it is possible that the high coefficients obtained in this study are partly a function of the range of age of the sample. A greater age spread makes a sample more heterogeneous and can lead to higher correlations than might be obtained with a more homogeneous sample. It is interesting to note that these latter two studies obtained moderate correlations. Is it possible that the results are a function of an interaction of test and sample ethnicity?

The measurement and prediction of infant abilities is a major focus of the Infant Studies Project. We have described elsewhere the purpose of the project and the measures that are being used to assess risk status in infancy

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(Parmelee, Kopp, Sigman, 1975). Relevant to the issue under discussion is our use of developmental and sensorimotor evaluations. These particular measures were chosen because clinically there seemed to be little overlap in the abilities that they tap, however, this thesis needed to be explored with data on infant performance. Therefore, the purpose of this paper is to report our initial analyses of the relationship of various facets of sensorimotor performance to abilities measured by a developmental examination for a sample of nine month old infants.[1] Since our sample is heterogenous in respect to organismic variables (term and pre-term births) and environmental factors, we also included comparison analyses of these variables. This report is concerned with three major questions: First, are there differences in the sensorimotor development of term and pre-term infants? Secondly, we wished to know if the internal structure of the sensorimotor scales could be defined by a single factor or by multiple factors. Finally, we asked whether sensorimotor scales provided an added dimension to the measurement of infant cognition above that provided by developmental assessment. In addition to examining intercorrelational data we explored the number of underlying variables inherent in both evaluations.

Subjects:

The subjects were 38 fullterm and 45 pre-term infants of singleton birth. The sample consisted of 85% Caucasian (30% Mexican-American), 8% Black, 4% Asian-American and 3% other. Many of the pre-term and some of the fullterm infants were participants in the Infant Studies Project. Other members of the sample were recruited from interested parents in the local community. All infants were tested when they were between 37 and 43 weeks of age (from their expected date of delivery); the mean age was 39.48 weeks with a standard deviation of 1.46 weeks. Only infants with an overall Developmental Quotient of greater than 90 were included in the analyses; the mean Developmental Quotient

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of the sample was 105.0 with a standard deviation of 6.66. A comparison analysis of pre-term and fullterm Developmental Quotients revealed a significant group difference: ft = 107, pt = 104, t (81) = 2.3, p < .02. However, this significance was due more to the size of the sample than to actual group differences as a test of statistical association showed only 5% of the variance in Developmental Quotient was accounted for by group differences, (ω^2 = .05). No sex differences were obtained. Most, but not all, of the infants were used in each of the reported analyses. Six full term infants who did not have the Gesell Developmental exam, although their estimated Developmental Quotient was above 90, could not be included in one analysis.

Description of research instruments:

Sensorimotor assessment: Sensorimotor behaviors were assessed using the "Stages of Sensory Motor Intelligence in the Child" developed by Casati and Lézine (1968). These authors attempted to construct a series with items that were characteristic of the thinking of each stage rather than those that isolated particular schemas of development. For the purpose of this study, three areas of performance involving four subtests were used. One test, search for hidden objects, is similar to other tests of object permanence (Gouin-Décarie, 1965; Uzgiris & Hunt, 1966). The other area of performance evaluated is called "use of intermediaries" and examines the child's ability to "see" a relationship between two objects in pursuit of a goal. One of the objects, a toy desired by the infant, is distant from him and accessible only by manipulation of an intermediary object that is nearby. The intermediaries consist of strings or a cloth and pivot. The two subtests in this performance area are called "use of extension of the object" (strings) and "use of the relationship between object and support" (object and support). Some of the items in these two tests are similar to items in the series called "Development of Means for Obtaining

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Events" developed by Uzgiris and Hunt (1966). Finally, exploration of objects is a single subtest which examines the child's ability to separate and then integrate components of an object. Scoring of the tests has been described in detail elsewhere (Kopp, Sigman, Parmelee, 1974).

Developmental assessment: The scores of the subtests of the Gesell Developmental examination were used for the major statistical analyses. This developmental examination was chosen because there are very few Piagetian type items within it. Furthermore, using the Gesell allows computation of developmental ability scores for five major areas: fine motor behavior, gross motor behavior, adaptive behavior, language behavior, and personal-social behavior. Computation of the individual subtest scores is similar to that used in deriving the overall Developmental Quotient.

Procedure:

All infants were tested at 9 months past their expected term date with the exception of 8 subjects whose Gesell scores were obtained between the ages of 44 and 53 weeks. Each infant was tested in the same examination rooms at UCLA. Testing times were chosen to suit the parent's convenience as well as their estimate of the child's most alert period during the day. For the sensorimotor series, the child was seated on his mother's lap before a table top covered with gray felt with the examiner sitting across from the baby. The mother was instructed not to give her baby any verbal or tactual cues during the test but she was encouraged to interact with the baby in accordance with her usual style.

Administration of the Gesell Developmental examination followed that of the sensorimotor series with a short break in between sessions. This exam was administered by a different examiner, in another testing room, with the infant seated in a standard crib. Test materials were presented to the infant on a

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gray wooden table top by an examiner standing to the side of the infant. Administration of both tests took about one hour.

Initial analysis were performed on both Gesell and Casati-Lézine scores in order to ensure that assumptions of factor analysis concerning sample distributions would not be violated. The means, standard deviations, and ranges of the scores for each of the subtests are presented in Table 1.

Statistical analyses:

1. Group differences in sensorimotor performance: To examine differences in sensorimotor ability between fullterm and pre-term infants, the scores on each of the four subtests of the Casati-Lézine series served as dependent variables in a one way multivariate analysis of variance (MANOVA) for disproportionate n's. The between-subject factor had three levels: fullterm infants-middle SES, n=28; pre-term infants-middle SES, n=26; and pre-term infants-low SES, n=19. Socio-economic status was determined using the mother's education with 12 years or more representing middle SES and less than 12 years defining low SES. A multivariate analysis was employed instead of individual F tests because scores on all four subtests obtained from every subject were correlated making a separate F test on each subtest statistically dependent. The multivariate test, however, is based on sample statistics that take into account the correlations between variables and has known exact sampling distributions from which exact probabilities can be obtained (Bock & Haggard, 1968).

2. Internal structure of the sensorimotor series: In order to determine the factorial structure of the Casati-Lézine series, all scores from the four subtests were intercorrelated across the entire sample of 83 subjects. Subsequently, a principal components analysis followed by orthogonal and oblique rotations and was performed on the Pearson product moment matrices. Both rotations were employed so that the restriction of orthogonality (independence) of

factors would not distort the component structure of subtests that might be related. The factor solution yielding the most easily interpretable results is reported.

3. Latent components derived from sensorimotor series and developmental exam: Scores from the subtests of the Gesell Developmental examination and the sensorimotor series for all subjects were intercorrelated (N = 77). A principal component analysis, with orthogonal and oblique rotations was performed on the correlation matrix.

Results:

1. Multivariate analysis of variance--group differences in sensorimotor performance: The multivariate analysis revealed no group differences. Therefore, the term and pre-term data were pooled for factorial analyses.

2. Principal Components Analysis--internal structure of Casati-Lézine series: Table 2 contains the intercorrelations of the four Casati-Lézine subtests for all subjects combined. Although statistically significant, the intercorrelations of the four subtests range from low to moderate in terms of the amount of variance accounted for. The principal components analysis of the subtests with orthogonol rotation produced a single factor and two variable solution accounting for 84 percent of the original variance (Table 3). The two subtests representing use of intermediaries constitute a single factor accounting for 44 percent of the total original variance with 22 percent of the variance explained by a second variable, exploration of objects. (The range of scores for the exploration subtest was restricted (0 to 3); therefore, the coefficients for exploration must be viewed with caution.) The third subtest, hidden objects, accounted for the final 18 percent of original variance. This suggests that sensorimotor intelligence as measured by Casati-Lézine series is not an undimensional construct, but is composed of several relatively independent

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variables. To eliminate a subtest would result in the loss of information. Further evidence to support this conclusion is provided by low squared multiple correlations of each variable with all other variables. No squared multiple correlation was above .21.

3. Principal components analysis--latent components of sensorimotor series and developmental examination: The intercorrelations among the Casati-Lézine subtests and the Gesell subscales for the total group are presented in Table 4.

Two major factors and a single variable emerged from an orthogonal rotation which explained 62 percent of the total original variance. The factors, along with their factor loadings after orthogonal rotation are presented in Table 5. The first factor, accounting for 31 percent of the variance represents a developmental ability factor composed of four of the Gesell subscales. A second factor containing all the subtests of the Casati-Lézine can be labeled a sensorimotor factor accounting for 17 percent of total variance. Finally, a single variable emerged that constitutes the developmental skill of gross motor ability. Taken together, these results suggest that while there is some overlap, the Gesell and Casati-Lézine scales are measuring different aspects of infant ability. In addition, gross motor behavior seems to be unrelated to both of these factors. It appears that sensorimotor evaluations measure abilities that differ from "traditional" developmental skills for a sample of nine month old babies.

Discussion:

The findings from this study of nine month old infants indicate that: subsets of sensorimotor abilities as measured by the Casati-Lézine series generally show low inter-relationships with each other and are defined structurally by multiple dimensions; and analyses of the relationship of these same abilities with five areas of Gesell performance show low association and can be explained as having a factor structure composed of a developmental dimension, a sensorimotor

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dimension, and a gross motor variable.

These initial findings can be construed as providing support for the developers of sensorimotor series who suggested that these measures could be used as a method to explore the organization of infant thought. Our findings suggest that there is some type of unifying ability, i.e. sensorimotor intelligence, underlying performance in comparison with overall developmental skills. Nonetheless, this sensorimotor ability is itself composed of different cognitive dimensions. Although these dimensions bear some inter-relationship with each other, the child can show more advanced development in one cognitive domain than in another. This, of course, is horizontal décalage described by Piaget and observed by others.

At the applied level, our data sustain the assumption that sensorimotor series can supply information above that given by developmental evaluations, thus, the use of these measures as a clinical aid is justified. Moreover, our findings indicate that the use of a single indicator of sensorimotor performance, e.g., object permanence, provides an insufficient index of infant abilities.

The question of the relationship between mental and motor abilities is not a new issue for psychology (Kagan, 1971; Kopp, 1975). Our findings of a gross motor variable that is relatively independent of sensorimotor and other developmental performance is support for those who have questioned the "tightness" of the relationship. However, it is also possible that the gross motor variable emerged because Gesell gross motor norms do not reflect general improvements in abilities of the contemporary infant. Knobloch and Pasamanick (1960) and Bayley (1965) observed some precocity on certain developmental items across generational cohorts. However, Knobloch and Pasamanick reported minor changes in almost all developmental areas measured by the Gesell for infants evaluated at 40 weeks of age. Our analyses differ from those made by the previous authors, nonetheless, the subjects in the present study show advanced perform-

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ance only in the area of gross motor abilities. It is interesting to note that Knobloch and Pasamanick suggest that gross motor performance might be the area of infant behavior most amenable to change, across cohorts, because of the improved nutritional and general medical status of more contemporary samples. Since our gross motor findings do not lend themselves to a clear cut interpretation we shall investigate this question further.

We have stressed that our findings are applicable, at the present time, for the age sample included in our study. Future analyses will be directed towards study of the relationship of sensorimotor and developmental performance with other age groups.

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Footnotes

1. In the near future we shall make similar analyses with data from infants at other ages.

Table 1

Means, Standard Deviations and Ranges of Casati-Lézine and Gesell Scores

			Mean	Standard Deviation	Range Minimum	Range Maximum
Casati-Lézine	1	Exploration	0.90	0.83	0.0	3.0
	2	Hidden Objects	3.64	2.63	0.0	9.5
	3	Strings	2.77	1.01	0.0	6.0
	4	Object and Support	2.50	1.33	0.0	6.5
Gesell	5	Gross Motor	121.90	15.50	83.0	156.0
	6	Fine Motor	101.70	9.76	83.0	144.0
	7	Adaptive	101.80	9.21	84.0	130.0
	8	Language	97.75	10.50	70.0	135.0
	9	Personal-Social	101.87	8.01	88.0	124.0

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Table 2

Intercorrelations of Casati-Lézine Subtests - Total Group

	Exploration	Hidden Object	Strings
Exploration			
Hidden Objects	.21*		
Strings	.14	.25*	
Object and Support	.29**	.31*	.33**

* p.05, two tailed

** p.01, two tailed

Table 3

Factor matrix resulting from Principal Component Analyses of Subtests from the Casati-Lézine Series - Total Group (Varimax rotation)

	Variance Accounted for		
	Factor 1	Factor 2	Factor 3
	(44%)	(22%)	(18%)
Object and Support	.58	.41	
Strings	.93		
Exploration	*	.96	
Hidden Objects			.97

* - loadings less than .40 omitted.

Table 4

Intercorrelations of Casati-Lézine Subtests with Subscales of Gesell Developmental Examination

	Exploration	Hidden Object	Strings	Object and Support	Gross Motor	Fine Motor	Adaptive	Language
Exploration								
Hidden Objects	0.220							
Strings	0.124	0.230						
Object and Support	0.363**	0.308**	0.340**					
Gross Motor	-0.017	0.237*	-0.122	0.094				
Fine Motor	-0.063	0.292*	0.224	0.211	0.028			
Adaptive	-0.166	0.209	0.182	0.195	-0.008	0.503**		
Language	-0.152	0.232*	0.083	0.137	-0.017	0.451**	0.370**	
Personal-Social	-0.029	0.315**	0.112	0.142	0.173	0.379**	0.498**	0.447**

* $p < .05$, two tailed

** $p < .01$, two tailed

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Table 5

Factor Matrix resulting from Principal Components Analysis of Casati-Lézine subtests and Gesell Developmental Subscales - Total Group (Varimax rotation)

	Variance accounted for		
	Factor 1	Factor 2	Factor 3
	(31%)	(17%)	(14%)
Adaptive	.78		
Fine Motor	.75		
Language	.74		
Personal-Social	.72		
Exploration	*	.73	
Objects and Support		.77	
Strings		.59	
Gross Motor			.89
Hidden Objects		.53	.42

* loadings less than .40 omitted